MAGANOM: A COMPUTER PROGRAM FOR THE MODELING AND INTERPRETATION OF MARINE MAGNETIC ANOMALIES

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Introduction

MAGANOM is a multi-purpose menu-driven interactive computer program for residual magnetic anomaly data processing and modeling. It is designed to model the magnetic anomalies above 2-dimensional magnetic bodies. The principal use of the program is to model sea floor spreading anomalies. It can also calculate and display the anomalies above magnetic bodies with irregular shapes. Designed primarily as a research tool, MAGANOM can also be used to teach the theory of magnetic anomaly formation at the undergraduate and graduate level.

This manual contains:

1) an introduction to the elements of MAGANOM,
2) instructions for the interactive use of MAGANOM,
3) a reference section on the options of the program,
4) sample sessions to guide the user,
5) a discussion of the theoretical basis of MAGANOM,
6) a discussion of the FORTRAN-77 source code of MAGANOM, and
7) a listing of the supplementary files used in the sample sessions.

1-1. The Fundamental Elements of MAGANOM

MAGANOM calculates a synthetic magnetic anomaly above magnetized bodies by one of two methods:

(a) calculation of the influence of each edge of each body at each observation point: "Edge Addition".

(b) Fourier domain filtering of a series of impulse signals representing the body: "Fourier Filtering".

Each method has special advantages and disadvantages. Edge Addition, while very slow at calculating sea floor spreading anomalies, is excellent at calculating the anomaly above irregularly shaped bodies (i.e. terrestrial anomalies). Fourier Filtering has some trouble calculating the effect of irregularly shaped bodies but is extremely fast at calculating sea floor spreading anomalies. Fourier filtering also allows for calculation of sea floor spreading anomalies above variable water/sea floor interface and the base of the magnetic layer interface. It will calculate seafloor spreading anomalies over irregular topography when the magnetic layer has either constant or variable thickness.

MAGANOM is designed to be interactive. The user may use either approach to solve his particular magnetics problem. The program permits a variety of pathways towards resolving the problem, as well as repeated calculations. By putting both approaches in the same program, the user can cross check the results with the other method and share between methods the filtering and plotting facilities that are also a part of the program. Solutions may be displayed at the terminal (Tektronix® or Tektronix® emulating) prior to generating paper copies of the results.

1-2. Running MAGANOM at Institute for Geophysics

To run MAGANOM, log onto the Institute VAX 11/780, set default to the directory to which you wish to send the plots and data files you create, then enter :

$ «RUN UTIG_EXE:MENUS»

Since this may be cumbersome, so I recommend that you set up a short cut in your LOGIN.COM file. Two possible ways of doing this are:

1) Enter <<$ MAGANOM:==RUN UTIG_EXE:MENUS>> in your login.com file, then type «MAGANOM» to run.

2) Enter <<$ ASSIGN UTIG_EXE:MENUS MAGANOM>> in your login.com file, then type «RUN MAGANOM» to run.

MAGANOM is almost entirely system independent. In other words, the program will run on any main-frame computer. The only part of MAGANOM that is system dependent are the plotting functions. MAGANOM uses the PLOTDFER package and PLOTT, PLOTV, and PLOTC programs provided to the Institute by Dr. Charles Denham. If you plan to use the plotting devices at the Institute to create and display plots created with MAGANOM, certain VAX logical assignments and pre-connections must be made before you start the program. I suggest that they be put in your LOGIN.COM file, so they will always be executed.

1) The assignment of a TEKTRONIX device is terminal dependant:

a) if you are working on a TEKTRONIX terminal or using a terminal that emulates a TEKTRONIX (like a Macintosh running VERSATERM), then enter <<ASSIGN TT: TEKDEV>>;

b) if you are not working at a TEKTRONIX, then enter <<ASSIGN TT**: TEKDEV>>, where ** is the logical name of the TEKTRONIX terminal.

2) The UTIG VAX offers three alternatives for making paper plots:

a) To use the VERSATEC plotter on campus, enter <<ASSIGN PLOTTER PLOTTER>>;

b) To use the VERSATEC plotter at the off-campus office, enter <<ASSIGN GAMBITA PLOTTER>>;

c) To use the CALCOMP plotter at the off-campus office, enter <<ASSIGN TTB2: PENDEV>>;

3) The plotting programs on the VAX must be pre-connected to MAGANOM in the following way:

a) <<$ PLOTT:==RUN UTIG_EXE:PLOTT>>

b) <<$ PLOTV:==RUN UTIG_EXE:PLOTV>>

c) <<$ PLOTC:==RUN UTIG_EXE:PLOTC>>

MAGANOM relies extensively on the UTIG PLOTDFER plotting package, the PATSY library of time series subroutines, and the VECTOR library of geographic subroutines. All of this software was provided by Dr. C.R. Denham. MAGANOM would not be possible with out it.

MAGANOM is also available at Woods Hole Oceanographic Institute (WHOI) and at the United States Geological Survey (USGS) in Woods Hole, Massachusetts. To use MAGANOM at these locations, please contact Dr. Hans Schouten (WHOI) or Dr. Kim Klitgord (USGS).

1-3. Interacting with MAGANOM

MAGANOM will ask the user for only four types of input: menu choices, filenames, simple yes or no answers in response to a question, or numbers.

Menu Choices: MAGANOM has a three-tiered menu system. Program functions are selected by entering a single letter that corresponds with a menu selection. The program starts at the first menu level. Any choice in the first level will move the user to the second level. After an operation has been completed in the second level, the user is either returned to the first level or the third level. Some functions at the second level require further user choices. These function move the user to the third menu level. After an operation in the third level is completed, the user is returned to the second menu level. The user then has the choice to do another operation in the second menu level or to return to first level.

Filenames: Program parameters and data are entered from files or from the terminal. When MAGANOM prompts for a parameter filename, the user may respond with (1) an appropriate VAX/VMS-type filename, (2) a carriage return («RET»), or (3) an asterisk («*»).

Filename: If a filename is entered, MAGANOM will read that file to update its variables names and/or to read new values.

Carriage return: If a carriage return («RET») is entered in response to a request for a filename, the variables are set to their default values. If any of the defaults values have been changed, the new values are preserved.

Asterisk: Typing an asterisk («*») initiates a function that allows variables to be altered directly from the terminal.

Simple answers: MAGANOM may prompt for yes/no responses. The responses should be a single letter («Y» or «N»). Upper case or lower case is acceptable.

Numbers: Some functions require the user to enter a number. Most queries are satisfied with an integer. If the response must be a real number, MAGANOM will say so.

1-3a. Working with the Variables of MAGANOM

Because MAGANOM is designed as a general purpose research tool, the user has been given access to almost every variable that MAGANOM can use in its calculations. This may cause some initial confusion, but it provides greater modeling flexibility in the end. All variables have reasonable default values. If you don't know what a variable does, leave it alone, because it is probably OK. A variable retains the value that the user has set it to as long as MAGANOM is running, or until the user changes it.

Variables or parameters may be addressed in three ways. First, the program frequently requests names of files containing variables. Reading these files updates the variables stored in the file. If a carriage return («RET») is typed, no values of the variables are changed. Typing an asterisks («*») in response to the request for a filename will initiate a function that allows the user to change individual parameters and variables at the terminal. In these cases, variables should appear as <<variable=value>>, with "value" as a floating point number and multiple equalities separated by commas. The "variable" may be in upper or lower case letters. An example of a variable entry (either in a file or at a terminal) is «PSHIFT=6.14, iptot=200.0». Any number of variables can be entered on any number of lines. Type <<CNTRL-Z>> to end the entry of variables when using terminal entry mode.

A second method by which the user can change the value of a variable occurs when the user displays the values of the variables by using the menu function that lists variables and their values. The variables are listed on the screen one page at a time. The user has the option to change the values of any of the variables listed, to exit the list, or to see and/or modify the next page.

Variables can be grouped into files by function (i.e. all plotting variables in one file, all filter variables in another...) and then read in when needed, or placed in one large file to be read in at the first prompt for a variables filename. Experience has shown the latter to be the more efficient method. If the user then wishes to iteratively change a group of key variables, then do so at the terminal, using the «*» response at the filename request.

Listed below are all the variables that are accessible to the user. Each variable is followed by a short description of what it does, then by its default value.

1-3a-1. General Variables -

Note: These are the variables a user is most likely to change.

Variable Name	Function	Default Value
SRATE	Spreading half rate, in mm/yr	70.00
AGEMIN	Minimum age to use from timescale, in Ma	-100.00
AGEMAX	Maximum age to use from timescale, in Ma	100.00
HWIDTH	Half width of Gaussian filter, in Km.	4.00
UPWARD	Amount of upward continuation, in Km.	0.00
PSHIFT	Schouten-MCamy phase shift, in degrees.	0.00
TOP	Top of magnetic layer, in Km.	3.00
BOTTOM	Bottom of magnetic layer, in Km.	5.00
STRIKE	Strike of ridge crest, in degrees.	90.00
NLAYERS	Number of layers in fourier topo raster	5
DATE	Date of observation, A.D.	1984.00
OLAT	Old latitude of observation, in degrees.	-30.00
PLAT	Present latitude of observation, in degrees	-30.00
PLON	Present longitude of observation, in degrees.	0.00
FPAGE	Age of fixed point, in Ma (NGDC output)	0.00
FPLAT	Lat. of fixed point, in De (NGDC output)	23.00
FPLON	Lon. of fixed point, in De (NGDC output)	10.00
HEADING	Heading from fixed point (NGDC output)	77.00
MAX_AMP	Max amplitude of output (NGDC output)	300.00
SAMPINT	Fourier sample interval,in Km.	1.00
BATHPOINTS	Number of observed bathymetry samples	1024
BLOCKPOINTS	Number of block model samples	4000
MAGPOINTS	Number of observed magnetic samples	1024

MANTPOINTS	Number of observed mantle samples	1024

1-3a-2. Plot Variables -

A negative value for a variable here will draw an axis that is as long in inches as the absolute value of the variable. For example, if SCALEF = -5.0, then the vertical scale of a filtered magnetic profile will be 5 inches long. If SCALEF = 300.0, then the vertical scale will be 300 gammas per inch.

Variable Name	Function	Default Value
SCALEXFLDS	Horiz. scale, calculated field, in km/in	-10.00
SCALEXOBS	Horiz. scale, observed field, in km/in	-10.00
SCALEXSYN	Horiz. scale, syn. blockmodel,in km/in	-10.00
SCALEB	Vert. scale, bathymetry profile, in km/in	-2.00
SCALEC	Vert. scale, calculated profile, in gamma/in	-2.00
SCALED	Vert. scale, difference profile, in gamma/in	-2.00
SCALEF	Vert. scale, filtered profile, in gammas/in	-2.00
SCALEM	Vert. scale, magnetization profile, in unit/in	-2.00
SCALEO	Vert. scale, observed profile, in gammas/in	-2.00

1-3a-3. Edge Addition Variables

Variable Name	Function	Default Value
ALT	Amount to shift observation level, in km.	5.00
AMAG1	Magnetization multiplicitive factor	1.00
AME	Regional magnetization (eastern component)	0.00
AMN	Regional magnetization (northern component)	0.00
AMZZ	Regional magnetization (vertical component)	-1.00
BRE	Block magnetization (eastern component)	0.00
BRN	Block magnetization (northern component)	0.00
BRZ	Block magnetization (vertical component)	5000.00
DISLIM	Max. sample search distance, in km.	50.00
DX	Sample interval for profile points, in km.	3.00
DXHI	Taper of central magnetic high, in km.	5.00

HMAG	Magnetization of central high, in gm.	10.00
IBTOT	Number of blocks in block model	100
ICTOT	Number of corners in block model	5
IPTOT	Number of observation points	400
ISETBR	International. Ref. Field flag. 0 is off	0
ISETMG	Body dipole calculation flag. 0 is off	0
ISFS	Seafloor spreading model flag. 0 is off	1
ITRUBL	Trouble flag. Expanded listing. 0 is off	0
IZBTOT	Number of points in bottom of slab	0
IZTOT	Number of points in top of slab	2
XPO	Origin offset to start calculations, in km.	0.00
XSHIFT	Observed profile origin offset, in km.	0.50

1-4. The Menu Choices and Functions of MAGANOM

MAGANOM generates and operates on data through a variety of separate functions. The sequence by which these functions are applied to the data is controlled by a series of menus. The program contains three levels of menus. The first menu level contains only one menu: the "Main Menu". This menu controls the overall flow of the program. Menus at the second and third level set up, modify, and apply individual functions. This approach allows great flexibility in applying functions and also provides quick and easy solutions to problems that require iterative solutions.

The first menu level provides general descriptions of the functions of MAGANOM (i.e. "Output profiles and/or variables"). Each general function at level one is a menu choice which in turn calls menus from the second menu level. The second menu level can only be reached from first menu level and provides access to specific functions (i.e. "Write profile data to output file or screen"). A menu in the third level can only be reached from a menu in the second level and provides access to particular actions of specific functions (i.e. "Profiles available for output to file or screen").

Listed below are all of the choices in all of the menu levels. Each menu list is preceded by a general description of the functions offered by that menu. Each menu choice is followed by information specific to the function that selection preforms. The listing is organized by menu level and order of appearance within a level. This section is designed for quick reference, as a guide to the user while running MAGANOM.

1-4-1. Menu Level 1 of MAGANOM

The first menu level of MAGANOM contains only the Main Menu. The program opens at this level. This menu provides access to all of the options that are available in MAGANOM. Each choice in this level (except "G") provides access to a menu at the second menu level.

1-4-1a. Main Menu

The flow of MAGANOM is controlled by the following menu:

A.) *Enter an anomaly, bathymetry, or base of magnetic crust interface profile*

Reads a profile from disk or terminal.

B.) *Enter a block model*

Reads a block model from disk or terminal.

C.) *Create a block model*

Creates a block model from the magnetic timescale.

D.) *Create an anomaly*

Creates a synthetic magnetic anomaly.

E.) *Filter an anomaly*

Filters a synthetic anomaly with a Gaussian, phase, or upward continuation filter.

F.) *Output profiles and/or variables*

Sets up display and output of profiles and/or variables.

G.) *Spawn a subprocess (leaving MAGANOM for a minute)*

Gives the user access to Digital Command Language (DCL) command line (the "$" prompt). Returns to MAGANOM upon completion of the command.

H.) *Exit*

Stops the program. Data is not saved.

1-4-2. Menu Level 2 of MAGANOM

The second level of menus in MAGANOM contains six menus. These menus provide access to specific functions summarized in the general description of the corresponding menu choice in the first menu level. Successful completion of an operation at this menu level will return the user to the first level, except the output menu (4-2f), which calls menus from the third menu level.

1-4-2a. Entering Profiles

The "Profile Entry Menu" provides access to all of the input functions of MAGANOM. The program will accept magnetic and/or topographic data from the terminal or from a file. The format of the data is as simple distance versus value pairs or as NGDC merged-merged format. The program offers the user the opportunity to interpolate the input data. When using the Fourier Filtering technique to calculate synthetic anomalies, all input data must be interpolated to the same Fourier frequency (i.e. the number of samples in each profile must be a power of 2: 128,512,1024...). Observed residual magnetic anomalies are stored in the "OBSERVED" data space. Topographic and base of the magnetic crust profiles are stored in the "BATHYMETRY" and "MANTLE" data spaces, respectively.

The menu choices and their functions are as follows:

A.) *Return to main menu*

Routes control to the Main Menu (1-4-1).

B.) *Enter magnetic data from a disk file (X-Y only)*

C.) *Enter magnetic data at terminal (X-Y only)*

D.) *Enter bathymetric data from a disk file (X-Y only)*

E.) *Enter bathymetric data at terminal (X-Y only)*

F.) *Enter magnetic and bathymetric data from a NGDC format file*

G.) *Enter base of magnetic crust data from a disk file (X-Y only)*

H.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-2b. Entering Block Models

The "Block Model Entry Menu" allow the user to enter an irregularly shaped model containing any number of blocks, with each block defined by an arbitrary number of sides. The synthetic anomaly associated with the model input here can only be calculated using the Edge Addition technique. The Fourier Filtering technique will not work on a model input in this format.

The program will accept data from the terminal or from a file. The format of the data must be as simple distance versus depth pairs, listed clockwise around each block. The first point and the last point of a block must be the same. The pairs are stored in the "BLOCKMODEL" data space.

The menu choices and their functions are as follows:

A.) *Return to main menu*

Routes control to the Main Menu (1-4-1).

B.) *Enter block corners from a disk file (X-Y only)*

C.) *Enter block corners from the terminal (X-Y only)*

D.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-2c. Creating Block Models

The "Block Model Creation Menu" instructs the program to generate a synthetic block model for calculating a seafloor spreading anomaly sequence. The program will select the portion of the geomagnetic timescale that is specified by the variables AGEMIN and AGEMAX. The flat top and bottom of the model is specified by TOP and BOTTOM. The blockmodel created is stored in the "BLOCKMODEL" data space.

The menu choices and their functions are as follows:

A.) *Return to main menu*

Routes control to the Main Menu (1-4-1).

B.) *Create edge addition block model with no topography*

Creates a simple block model for the Edge Addition technique using the geomagnetic timescale.

C.) *Create Fourier block model with no topography*

Creates a simple block model for the Fourier Filtering technique using the geomagnetic timescale.

D) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-2d. Calculating Magnetic Anomalies

The "Anomaly Creation Menu" instructs the program to calculate a synthetic magnetic anomaly using either Fourier Filtering (Section 1-6-1) or Edge Addition (Section 1-6-2). The anomaly is calculated based on either the model entered with the "Block Model Entry" menu, the block model created with the "Block Model Creation" menu, or the topographic profiles entered with the "Profile Entry" menu. If no model exists (i.e. it hasn't been previously created or entered) for calculations based on simple block models, MAGANOM will create one before synthetic anomaly calculations begin. For modified Fourier Filtering, the bathymetric and/or base of the magnetic crust profiles must be entered before the calculation begins. The synthetic anomaly created is stored in the "CALCULATED" data space.

The menu choices and their functions are as follows:

A.) *Return to main menu*

Routes control to the Main Menu (1-4-1).

B.) *Create an anomaly by Edge Addition*

Creates a synthetic anomaly using Edge Addition method (See Section 1-6-2).

C.) *Create an anomaly by Fourier Filtering, with a flat top and bottom*

Creates a synthetic anomaly using the simple Fourier Filtering method (See Section 1-6-1).

D.) *Create an anomaly by Fourier Filtering, with topography and a flat bottom*

Creates a synthetic anomaly using the modified Fourier Filtering method (See Section 1-6-1). This option incorporates observed topography and therefore accounts for magnetic material excesses and deficiencies caused by that topography. The base of the magnetic layer is assumed to be horizontal, set at a depth of BOTTOM.

E.)*Create an anomaly by Fourier Filtering, with topography and a base of magnetic crust interface that mimics topography*

Creates a synthetic anomaly using the modified Fourier Filtering method (See Section 1-6-1). This option also incorporates observed topography. The base of the magnetic layer is assumed to mimic the topography. The thickness of the magnetic layer will be (TOP minus BOTTOM).

F.) *Create an anomaly by Fourier Filtering, with separate topography and base of magnetic crust interface*

Creates a synthetic anomaly using the modified Fourier Filtering method (See Section 1-6-1). This option also incorporates observed topography and base of the magnetic layer and therefore accounts for magnetic material excesses and deficiencies caused by a magnetic layer of variable thickness.

G.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-2e. Filtering Magnetic Anomalies

After MAGANOM has calculated a synthetic anomaly, the user may wish to filter it. The "Anomaly Filtering Menu" offers a choice of several filters that may be applied to the synthetic magnetic anomaly. The effects of various filters are outlined pictorially in section 1-6-3. After the user has chosen a filter, the program gives the option of applying that filter to the synthetic anomaly or to an already filtered synthetic anomaly. This effectively allows the user to filter twice any synthetic anomaly, with the same filter, or with different filters. If the user filters the synthetic anomaly, the result is stored in the "FILTERED" data space. If the user filters an already filtered anomaly, the output is stored in the "FILTERED2" data space.

The menu choices and their functions are as follows:

A.) *Return to main menu*

Routes control to the Main Menu (1-4-1).

B.) *with Earth filter*

Filters the synthetic or filtered anomaly with the "Earth filter" (Schouten, 1971). The filter parameters are set by the variables TOP, BOTTOM, UPWARD, and PSHIFT.

C.) *with Phase filter*

Filters the synthetic or filtered anomaly with the "Phase filter" (Schouten,1971), also known as "Phase Shift". MAGANOM offers the user the option of calculating the phase shift based on PLAT, PLON, OLAT, and STRIKE, or applying the phase shift already stored in the variable PSHIFT. If the user calculates a new phase shift, the old value of PSHIFT is replaced with the new value.

D.) *with Upward and Downward Continuation*

Filters the synthetic or filtered anomaly with a logarithmic decay filter (Schouten, 1971). The amount of continuation applied is stored in the variable UPWARD. If UPWARD is negative, downward continuation will be applied. **Beware!!** The use of downward continuation to enhance a signal is inherently unstable and should be done with the greatest of care. If the user attempts to use too much downward continuation, the program will get an arithmetic error and abort, **losing all previously stored and/or created data**.

E.) *with Gaussian distribution filter*

Filters the synthetic or filtered anomaly with a Gaussian curve filter (Tapscott, et al., 1980). The halfwidth (standard deviation) of the curved is stored in the variable HWIDTH. The effect of the filter is to simulate a symmetric bell-shaped dike intrusion pattern rather than the abrupt polarity transition that is used when the calculation of the synthetic anomaly is originally made.

F.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-2f. Making Plots and Printouts

The "Output Menu" provides access to all of the output functions of MAGANOM. The program offers the user the option to make plots of profiles, to create data files of the profiles, or to create data files that contain the variable names and their current values. The user can also list profiles or variables to the terminal. The type of plotting devices is also controlled with this menu.

The menu choices and their functions are as follows:

A.) *Return to main menu*

Routes control to the Main Menu (1-4-1).

B.) *Change default plotting device*

Routes control to the menu that controls the default display device (the "Change Default Plotter" menu, Section 1-5-3a).

C.) *Build plot file, then (optionally) plot*

Routes control to the "Profiles Available for Plotting" menu (Section 1-5-3b).

D.) *Write profile data to an output file or the screen*

Routes control to the "Writing Profiles to Screen and Output Files" menu (Section 1-5-3c).

E.) *Write (to a file or screen) and/or change present variables*

This choice instructs the program to write a list of the present values of all the variables to a file or to the terminal. If no values have been changed, the default values will be listed. If changes have been made, the list will reflect the new values. This choice is useful to document exactly what the user has done, and to catch errors.

If the user chooses to list the variables to the terminal, MAGANOM will display a page of information at a time, and at the end of each page, will ask the user if he wants to display more values (default), to quit listing the values, or to change values. Variable values can be changed by simply typing the name of the variable (upper or lower case), an equals sign ("="), the new value to which the variable should be set (as a floating point number), and a carriage return ("<<RET>>"). A list of variables can be changed on a single line if the variables and their values are separated by a comma.

F.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-3. Menu Level 3 of MAGANOM

The third level of MAGANOM contains three menus. These menus provide access to specific output options from the output menu in the second menu level. The user can only reach this menu level by choosing "F" ("Making Plots and Printouts") from the main menu level and choosing any option (except "E") from the output menu of the second level. Successful completion of an operation at this menu level will return the user to the output menu of the second level.

1-4-3a. Generating Plotted Profiles

The "Profiles Available for Plotting Menu" presents the user with a menu of all the profiles available for plotting (block model, bathymetry, calculated field...), as well as the option to plot them on the default plotting device. This menu may be used at any time during a run of MAGANOM, and any item may be selected an unlimited number of times.

MAGANOM uses the UTIG PLOTDFER plotting package. This means that the program will not display the data as it creates the plot. Instead, MAGANOM creates a deferred plot file (called FOR095.DAT) that contains a journal of all of the drawing commands issued for a particular plot. After all of the drawing commands have been compiled in the deferred plot file, a separate program (PLOTT, PLOTV, or PLOTC) must be run to see the plot on the default plotting device.

This menu is the interface between the UTIG plotting package and the profiles entered or created by the user in MAGANOM. Each time the user chooses to plot a profile offered in this menu, the program compiles the drawing in the deferred plot file, then cycles back to this menu. If the user chooses to plot another profile in this menu, the program stacks the drawing above the previous plot at a common scale and appends the drawing commands to the deferred plot file. If the user chooses to plot the profiles already chosen (choice "I"), MAGANOM call the appropriate plotting program (PLOTT, PLOTV, PLOTC) for the default plotting device. The scaling of the plot axes is controlled by variables SCALEXFLDS, SCALEXOBS, SCALEXSYN, SCALEB, SCALEC, SCALED, SCALEF, SCALEM, and SCALEO.

The menu choices and their functions are as follows:

A.) *Return to output menu*

Routes control to the Output Menu (1-4-2f).

B.) *Block model*

Adds a distance vs. polarity profile to the plot file.

C.) *Bathymetry*

Adds a distance vs. depth profile to the plot file.

D.) *Observed field*

Adds a distance vs. observed field strength profile to the deferred plot file.

E.) *Calculated field*

Adds a distance vs. synthetic field profile to the deferred plot file.

F.) *Filtered field*

Adds a distance vs. filtered synthetic field profile to the deferred plot file.

G.) *Filtered-filtered field*

Adds a distance vs. twice filtered synthetic field profile to the deferred plot file.

H.) *Difference between observed and calculated field*

Adds a distance vs. difference between observed and calculated profile to the deferred plot file.

I.) *Plot profiles chosen*

Closes the deferred plot file, then calls the appropriate plotting program. If this choice selected without any other menu choices, the last deferred plot file will be displayed.

J.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-3b. Setting Up Plotting Devices

The "Change Default Plotter Menu" allows the user change the default plotting device. The default device is the Tektronix® screen.

The menu choices and their functions are as follows:

A.) *Return to output menu*

Routes control to the Output Menu (1-4-2f).

B.) *Change to Versatec ® Plotter*

Changes the default plotter to the Versatec® paper plotter. To plot on campus, the logical name PLOTTER must be assigned to PLOTTER before MAGANOM is started (i.e. $ <<ASSIGN PLOTTER PLOTTER>>). To plot at the UTIG offices, the logical name PLOTTER must be assigned to GAMBITA (i.e. $ <<ASSIGN GAMBITA PLOTTER>>). The Versatec® dimensions are unlimited in the X - direction but are constrained to 18 inch wide panels in the Y-direction.

C.) *Change to Tektronix ® Plotter*

Changes the default plotter to a Tektronix® screen. If the user is working at a Tektronix terminal (or using a program to emulate a Tektronix), the logical name TEKDEV must be assigned to TT: before MAGANOM is started. If the user is working at a non-Tektronix terminal, the logical name TEKDEV must be assigned to TT**, where ** is the logical name of the Tektronix terminal screen. The Tektronix display independently scales the x and y dimensions of the plot to fit within the 10" (x) by 12" (y) screen.

D.) *Change to Gould DeAnza Plotter*

Changes the default plotter to the color Gould-DeAnza display screen. The logical name PLTDEV must be assigned to TTC7: before MAGANOM is started. The Gould-DeAnza screen scales the plot to fit within its 10 by 12 inch display surface in the same manner as does the Tektronix devices.

E.) *Change to Calcomp Plotter*

Changes the default plotting device to the Calcomp paper plotter. The logical name PENDEV must be assigned to TTB2: before MAGANOM is started. The Calcomp plotter has a display surface that is 60 inches in the X - direction and 36 inches in the Y - direction.

F.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-4-3c. Writing Profiles to Screen and Output Files

The "Write Profile Data to an Output File or the Screen Menu" allows the user to write to a file or the terminal a listing of the values contained in any of the profiles entered or created in MAGANOM. The program will give the user the option to output the data as either X - (distance) versus Y (value) free-format real number pairs or as a NGDC merged-merged format file. The X-Y pairs are useful as a simple check of the values entered or calculated by MAGANOM. NGDC format allows MAGANOM to generate data compatible with standard marine data mapping programs.

In the case of output as NGDC files, the values of the profile chosen are put in the "magnetic anomaly" field of the merged - merged format. The observed bathymetry is put in the "corrected meters" field, and the observed residual magnetic anomaly is put in the "residual anomaly" field. The profile runs in the direction of the variable HEADING and is fixed at age along the profile specified by FPAGE, at the latitude and longitude point (the "Fixed Point") specified by FPLAT, FPLON. The length of the profile is based on SRATE. Note: The only control the user has on the length of the profile is through SRATE, AGEMIN, AGEMAX. The start of the profile is ((AGEMIN - FPAGE) * SRATE) kilometers from the fixed point, and the end of the profile is ((AGEMAX - FPAGE) * SRATE) kilometers from the fixed point.

The menu choices and their functions are as follows:

A.) *Return to output menu*

Routes control to the Output Menu (1-4-2f).

B.) *Block model*

Writes a distance vs. polarity profile to disk as X-Y pairs. This choice has no effect if NGDC format is chosen.

C.) *Bathymetry*

Writes a distance vs. depth profile to disk as X-Y pairs. This choice has no effect if NGDC format is chosen.

D.) *Observed field*

Writes a distance vs. observed field strength profile to disk as X-Y pairs. This choice has no effect if NGDC format is chosen.

E.) *Calculated field*

Writes a distance vs. synthetic field profile to disk as X-Y pairs or in NGDC format.

F.) *Filtered field*

Writes a distance vs. filtered synthetic profile to disk as X-Y pairs or in NGDC format.

G.) *Filtered-filtered field*

Writes a distance vs. twice filtered synthetic profile to disk as X-Y pairs or in NGDC format.

H.) *Difference between observed and calculated field*

Writes a distance vs. difference between observed and calculated profile to disk as X-Y pairs or in NGDC format.

I.) *Exit from MAGANOM*

Stops the program. Data is not saved.

1-5. Sample runs of MAGANOM

Listed below are samples of sessions of modeling seafloor spreading magnetic anomalies with MAGANOM. Each sample is a complete step-by-step outline of how MAGANOM can be used to solve a problem. Output from the computer is in plain text (OUTPUT). Input from the user is in bold text and is underlined (<u>**RESPONSE**</u>). Comments on why a particular function was chosen appear as italicized text (*COMMENT*).

1-5-1. Simple modeling of ELTANIN 19, South Pacific

The first sample involves modeling the seafloor spreading magnetic anomaly above the ridge crest of the East Pacific Rise near latitude south 30°. This profile is considered to be a classic by many geologists as it was one of the first used to describe sea floor spreading magnetic anomalies. A simple block model is used to model the ocean crust. The location of the present spreading axis is based on topography and seismicity, and is located at the right-hand edge of the observed profile. It is assigned an age of zero. The age on the western edge of the observed profile is unknown. The objective of this example to determine the age of the crust on the western edge of the observed profile.

$ **MAGANOM** *(Start program)*

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **A** *(Input of observed profile)*

Profile entry Menu:

A.) Return to main menu

B.) Enter magnetic data from a disk file (X-Y only)

C.) Enter magnetic data from the terminal

D.) Enter bathymetric data from a disk file (X-Y only)

E.) Enter bathymetric data from the terminal

F.) Enter magnetics and bathymetry data from a NGDC format file

G.) Enter mantle interface data from a disk file (X-Y only)

H.) Exit from MAGANOM

Choice > **B**

Enter disk file name <MDATA.DAT>: **ELOBS.DAT**

Would you like to interpolate (Y or N) ? **Y**

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>

.... VAX VERSION AUGUST, 1981 .... *(PATSY does the interpolation)*

NWORKING =499997;INDEX = 2;IRESET = 2

Interpolate to how many?

REMEMBER- Must be 2**N for Fourier calculation

512 *(Must interpolate observed to Fourier frequency because synthetic will be created using Fourier Filtering)*

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **D**

Anomaly creation Menu:

A.) Return to main menu

B.) Create an anomaly by edge addition

C.) Create an anomaly by Fourier smoothing, flat top and bottom

D.) Create an anomaly by Fourier smoothing, with topography and flat bottom

E.) Create an anomaly by Fourier smoothing, with topography and bottom mimics topography

F.) Create an anomaly by Fourier smoothing, with separate topography and bottom

G.) Exit from MAGANOM

Choice > **C** *(Calculation will be made based on a simple square wave)*

Enter filename that contains anomaly variables

<DEFAULT VALUES>: **ELTANIN.DAT** *(File contains all variables to be reset. Variables are set to best guess)*

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>

.... VAX VERSION AUGUST, 1981 .... *(PATSY does the calculation)*

NWORKING =499997;INDEX = 2;IRESET = 2

Main Menu:

\----------

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **E**

Anomaly filtering Menu:

\----------------------

A.) Return to main menu

B.) with Hans Schoutens Earth filter

C.) with Phase Filter

D.) with Upward/Downward Continuation

E.) with Gaussian distribution

F.) Exit from MAGANOM

Choice > **E**

Do you wish to filter the filtered array (Y or N) ?

DEFAULT= "N" *(This will filter synthetic with Gaussian curve*

<RET> *to simulate random dike intrusion*)

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>

.... VAX VERSION AUGUST, 1981 .... (*PATSY does the filtering*)

NWORKING =499997;INDEX = 2;IRESET = 2

Enter file name with filter variables "*" to read from term. <DEFAULT> :

<RET> (*All values of variable have been set already*)

Main Menu: *(User now has a synthetic profile)*

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **F**

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **C** *(Output will be as a plotted profile)*

Profiles available for plotting :

A.) Return to output menu

B.) Block model

C.) Bathymetry

D.) Observed field

E.) Calculated field

F.) Filtered field

G.) Filtered filtered field

H.) Difference between observed and calculated

I.) Plot profiles chosen

J.) Exit from MAGANOM

Enter profiles as a list, separated by commas, up to 9 (I.E. A,B,C,D,I)

Choices > **D,F,I** (*Two stacked profiles and top label will be plotted on Tektronix screen plotter)*

PLOTT 1.6 Mar 82; U.T.I.G. Version Sept 83.

For <plotdfer> file with logical-name FOR095. (*PLOTT handles the display*)

Defaults: No pause, auto-window, go.

ENTER SIZE_FACTOR, FIRST_SUB_IMAGE, LAST_SUB_IMAGE: **<RET>**

PAUSE BETWEEN SUB_IMAGES? (Y OR N): **<RET>**

CALCULATE AUTO_WINDOW? (Y OR N): **<RET>**

X_ORIGIN = -0.5320415 Y_ORIGIN = -0.7700166

X_LENGTH = 5.202082 Y_LENGTH = 8.033045 INCHES.

W FOR WINDOW, G FOR GO: **<RET>**

(*SEE FIGURE 1*)

G FOR GO,C FOR CURSOR (O=LOWER-LEFT; W=UPPER-RIGHT), W FOR WINDOW, F FOR FIRST W, Q FOR QUIT: **Q**

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **A** (*Go back to main and create new synthetic*)

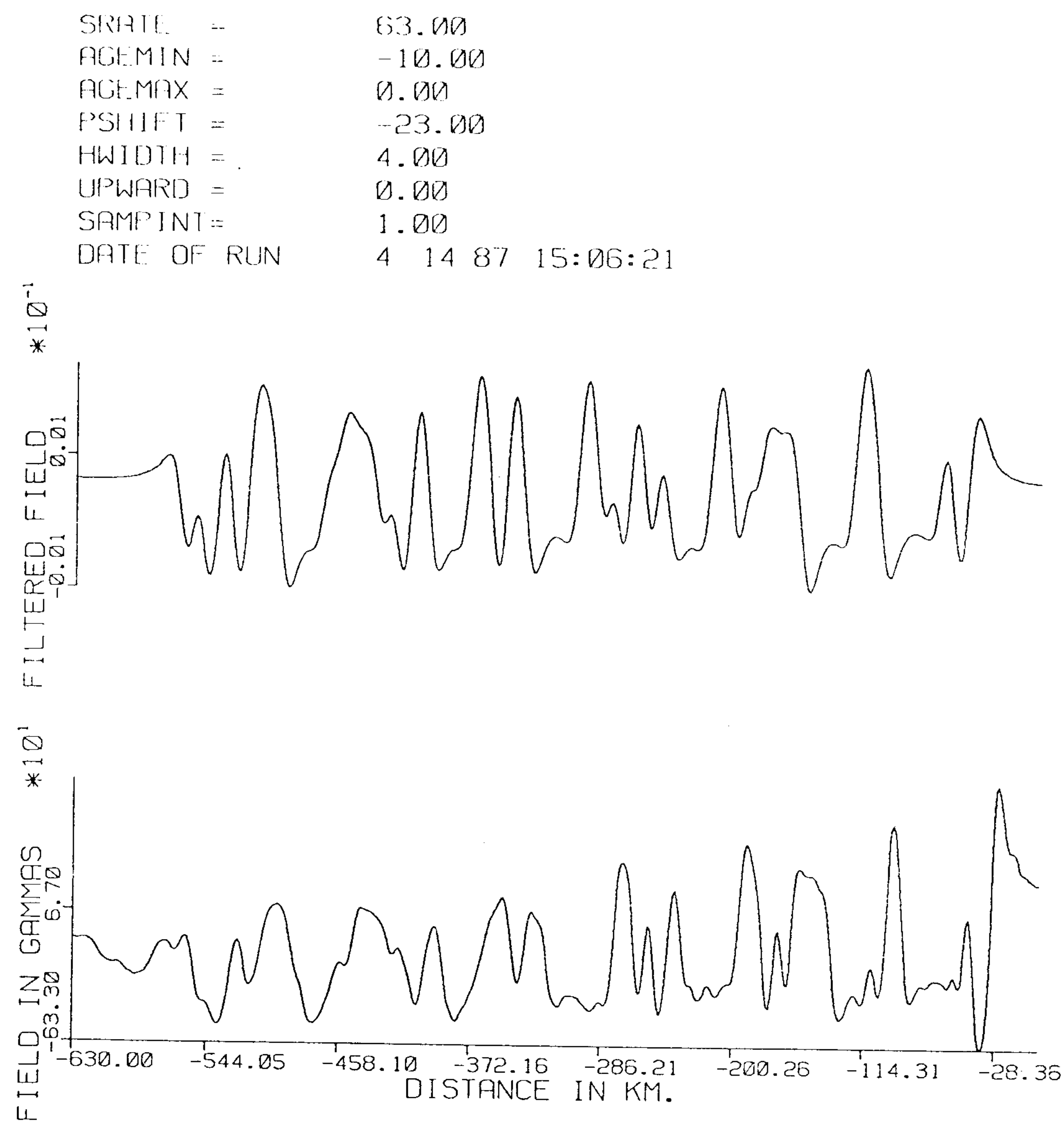

Figure 1. First attempt at modelling using the simple Fourier method. The left hand age of the synthetic seems to be too young, and the amplitude (y-scale) of the filtered synthetic seems to be too large.

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **D** (*Create new synthetic based on errors in old*)

Anomaly creation Menu:

A.) Return to main menu

B.) Create an anomaly by edge addition

C.) Create an anomaly by Fourier smoothing, flat top and bottom

D.) Create an anomaly by Fourier smoothing, with topography and flat bottom

E.) Create an anomaly by Fourier smoothing, with topography and bottom mimics topography

F.) Create an anomaly by Fourier smoothing, with separate topography and bottom

G.) Exit from MAGANOM

Choice > **C**

Enter filename that contains anomaly variables

<DEFAULT VALUES>: ***** (*Make changes at terminal*)

Enter values to be changed, always real, separated by a comma.

AGEMIN=-10.0 (*Reduce left-hand age*)

SCALEF= 0.0020 (*Increase filtered plot scale factor*)

< CNTRL - Z > (*End list of changes, calculate synthetic*)

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>

.... VAX VERSION AUGUST, 1981 ....

NWORKING =499997;INDEX = 2;IRESET = 2

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **E** *(Filter as before)*

Anomaly filtering Menu:

A.) Return to main menu

B.) with Hans Schoutens Earth filter

C.) with Phase Filter

D.) with Upward/Downward Continuation

E.) with Gaussian distribution

F.) Exit from MAGANOM

Choice > **E**

Do you wish to filter the filtered array (Y or N) ?

DEFAULT= "N"

<RET>

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>

.... VAX VERSION AUGUST, 1981 ....

NWORKING =499997;INDEX = 2;IRESET = 2

Enter file name with filter variables "*" to read from term. <DEFAULT> :

<RET>

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **F** *(Display as before)*

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **C**

Profiles available for plotting :

A.) Return to output menu

B.) Block model

C.) Bathymetry

D.) Observed field

E.) Calculated field

F.) Filtered field

G.) Filtered filtered field

H.) Difference between observed and calculated

I.) Plot profiles chosen

J.) Exit from MAGANOM

Enter profiles as a list, separated by commas, up to 9 (i.e. A,B,C,D,I)

Choices > **D,F,I**

PLOTT 1.6 Mar 82; U.T.I.G. Version Sept 83.

For <plotdfer> file with logical-name FOR095.

Defaults: No pause, auto-window, go.

ENTER SIZE_FACTOR, FIRST_SUB_IMAGE, LAST_SUB_IMAGE: **<RET>**

PAUSE BETWEEN SUB_IMAGES? (Y OR N): **<RET>**

CALCULATE AUTO_WINDOW? (Y OR N): **<RET>**

X_ORIGIN = -0.5320415 Y_ORIGIN = -0.7831751

X_LENGTH = 5.202082 Y_LENGTH = 8.717283 INCHES.

W FOR WINDOW, G FOR GO: **<RET>**

(*SEE FIGURE 2*)

G FOR GO, C FOR CURSOR (O=LOWER-LEFT; W=UPPER-RIGHT), W FOR WINDOW, F FOR FIRST W, Q FOR QUIT: **Q**

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **E** (*Output variables of calculation so user has permanent record and can repeat result*)

Enter filename for output, * for term <*>: **<RET>**

General Variables

Variable Name	Function	Present Value
SRATE	Spreading half rate, in mm/yr	63.00
AGEMIN	Minimum age to use from timescale, in Ma	-10.00

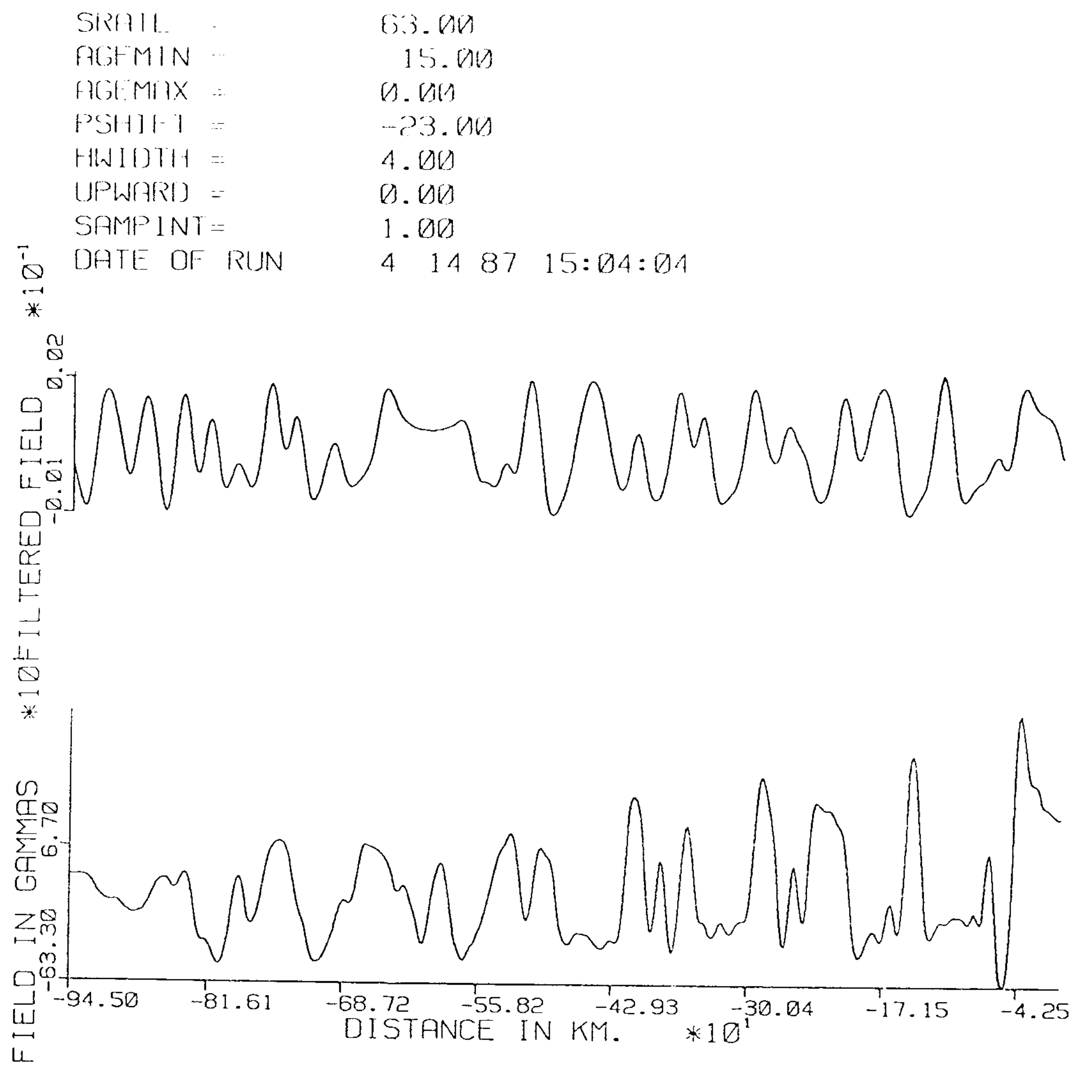

Figure 2. Second attempt at modelling using the simple Fourier method. The result is excellent. First and second order peaks seem to correlate.

AGEMAX	Maximum age to use from timescale, in Ma	0.00
HWIDTH	Half width of Gaussian filter, in Km.	4.00
UPWARD	Amount of upward continuation, in Km.	0.00
PSHIFT	Schouten-MCamy phase shift, in degrees.	-23.00
TOP	Top of magnetic layer, in Km.	3.20
BOTTOM	Bottom of magnetic layer, in Km.	4.00
STRIKE	Strike of ridge crest, in degrees.	40.00
NLAYERS	Number of layers in Fourier topo raster	5
DATE	Date of observation, A.D.	1962.0
OLAT	Old latitude of observation, in degrees.	-30.00
PLAT	Present latitude of observation, in degrees.	-30.00
PLON	Present longitude of observation, in degrees.	0.00
FPAGE	Age of fixed point, in Ma (NGDC output)	0.00
FPLAT	Lat. of fixed point, in De (NGDC output)	23.00
FPLON	Lon. of fixed point, in De (NGDC output)	10.00
HEADING	Heading from fixed point (NGDC output)	77.00
MAX_AMP	Max amplitude of output (NGDC output)	300.00

Type <RET> to continue list or enter variable
name and new value as a real number, separated by =
to change (I.E. SRATE=23.1). Type <Q> or <q> to quit list
Type <L> or <l> to type this part of the list again.

<u><RET></u> (*See next page of variables*)

Variable Name	Function	Present Value
SAMPINT	Fourier sample interval,in Km.	1.00
BATHPOINTS	Number of observed bathymetry samples	512
BLOCKPOINTS	Number of block model samples	512
MAGPOINTS	Number of observed magnetic samples	512
MANTPOINTS	Number of observed mantle samples	512

Plot Variables

Variable Name	Function	Present Value
SCALEXFLDS	Horiz. scale, calculated field, in km/in	240.00
SCALEXOBS	Horiz. scale, observed field, in km/in	240.00

SCALEXSYN	Horiz. scale, syn. blockmodel,in km/in	240.00
SCALEB	Vert. scale, bathymetry profile, in km/in	1.50
SCALEC	Vert. scale, calculated profile, in gm/in	-2.00
SCALED	Vert. scale, difference profile, in gm/in	-2.00
SCALEF	Vert. scale, filtered profile, in gm/in	0.00
SCALEO	Vert. scale, observed profile, in gm/in	700.00

Type <RET> to continue list or enter variable
name and new value as a real number, separated by =
to change (I.E. SRATE=23.1). Type <Q> or <q> to quit list
Type <L> or <l> to type this part of the list again.
Q (*End of listing function*)

Output Menu:

A.) Return to main menu
B.) Change default plotting device (now is: plott)
C.) Build plot file, then (optionally) plot with plott
D.) Write profile data to an output file or screen
E.) Write (to file or screen) and/or change present variables
F.) Exit from MAGANOM
Choice > **F** (*End of simple example*)

1-5-2. Complex modeling of ELTANIN 19, South Pacific

The second sample involves modeling the seafloor spreading magnetic anomaly above the ridge crest of the East Pacific Rise near latitude 30° south. It is the same profile modelled by Pitman, Herrron, and Hiertzler (1968). A complex model is used which incorporates the magnetic polarity reversals into a crust that is of constant thickness but has topography. The topography of the magnetic layer is controlled by the bathymetry observed on the line that will be modelled. The location of the present ridge axis is based on topography and seismicity, and is somewhere in the middle of the observed profile that will be modelled. The objective of this example is to determine the complete age distribution on this line.

$ **MAGANOM** (*Start program*)

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile
B.) Enter a blockmodel
C.) Create a blockmodel
D.) Create an anomaly
E.) Filter an anomaly
F.) Output profiles and/or variables
G.) Spawn a subprocess (leave MAGANOM for a minute)
H.) Exit from MAGANOM
    Choice > **A** (*Input of observed profiles*)

Profile entry Menu:

A.) Return to main menu
B.) Enter magnetic data from a disk file (X-Y only)
C.) Enter magnetic data from the terminal
D.) Enter bathymetric data from a disk file (X-Y only)
E.) Enter bathymetric data from the terminal
F.) Enter magnetics and bathymetry data from a NDSGC format file
G.) Enter mantle interface data from a disk file (X-Y only)
H.) Exit from MAGANOM
    Choice > **F** (*Input of data as NGDC will get b athymetry and observed*)
Enter filename of NDSGC data <NDSGC.DAT> : **CAR:EL019.DAT**
There are 726 points in the file.
How many would you like to interpolate to ? **1024** (*A Fourier* <<<<<<<<<<
PATSY TIME-SERIES PROCESSOR >>>>>>>>>> *frequency*)
.... VAX VERSION AUGUST, 1981 .... (*PATSY does the interpolation*)
NWORKING = 99997;INDEX = 2;IRESET = 2

Main Menu:

\----------

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **D**

Anomaly creation Menu:

\---------------------

A.) Return to main menu.

B.) Create an anomaly by edge addition

C.) Create an anomaly by Fourier smoothing, flat top and bottom

D.) Create an anomaly by Fourier smoothing, with topography and flat bottom

E.) Create an anomaly by Fourier smoothing, with topography and bottom mimics topography

F.) Create an anomaly by Fourier smoothing, with separate topography and bottom

G.) Exit from MAGANOM

Choice > **E** *(Calculation will be made based*

Enter filename that contains anomaly variables, *on complex constant*

* to read in variable changes from terminal. *thickness slab)*

<DEFAULT VALUES>: **CAYMAN:COMPLEX_EXAMPLE.DAT** *(File contains all variables to be reset. Variables are set to best guess)*

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>

.... VAX VERSION AUGUST, 1981 .... *(PATSY does the calculation)*

NWORKING =499997;INDEX = 2;IRESET = 2

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **E**

Anomaly filtering Menu:

A.) Return to main menu

B.) with Hans Schoutens Earth filter

C.) with Phase Filter

D.) with Upward/Downward Continuation

E.) with Gaussian distribution

F.) Exit from MAGANOM

Choice > **E**

Do you wish to filter the filtered array (Y or N) ?

DEFAULT= "N" *(This will filter synthetic with Gaussian curve*

<RET> *to simulate random dike intrusion*)

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>

.... VAX VERSION AUGUST, 1981 .... (*PATSY does the filtering*)

NWORKING =499997;INDEX = 2;IRESET = 2

Enter file name with filter variables "*" to read from term. <DEFAULT> :

<RET> (*All values of variable have been set already*)

Main Menu: (*User now has a synthetic profile*)

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **F**

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **C** (*Output will be as a plotted profile*)

Profiles available for plotting :

A.) Return to output menu

B.) Block model

C.) Bathymetry

D.) Observed field

E.) Calculated field

F.) Filtered field

G.) Filtered filtered field

H.) Difference between observed and calculated

I.) Plot profiles chosen

J.) Exit from MAGANOM

Enter profiles as a list, separated by commas, up to 9 (I.E. A,B,C,D,I)

Choices > **B,C,D,F,I** (*Four stacked profiles and top label will be plotted on Tektronix screen plotter*)

PLOTT 1.6 Mar 82; U.T.I.G. Version Sept 83. (*PLOTT handles the display*)

For <plotdfer> file with logical-name FOR095.

Defaults: No pause, auto-window, go.

ENTER SIZE_FACTOR, FIRST_SUB_IMAGE, LAST_SUB_IMAGE: **<RET>**

PAUSE BETWEEN SUB_IMAGES? (Y OR N): **<RET>**

CALCULATE AUTO_WINDOW? (Y OR N): **<RET>**

X_ORIGIN = -0.6312424 Y_ORIGIN = -0.7884752

X_LENGTH = 10.36048 Y_LENGTH = 17.42736 INCHES.

W FOR WINDOW, G FOR GO: **<RET>**

(SEE FIGURE 3)

G FOR GO, C FOR CURSOR (O=LOWER-LEFT; W=UPPER-RIGHT), W FOR WINDOW, F FOR FIRST W, Q FOR QUIT: **Q**

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **A** (*Go back to main and create new synthetic*)

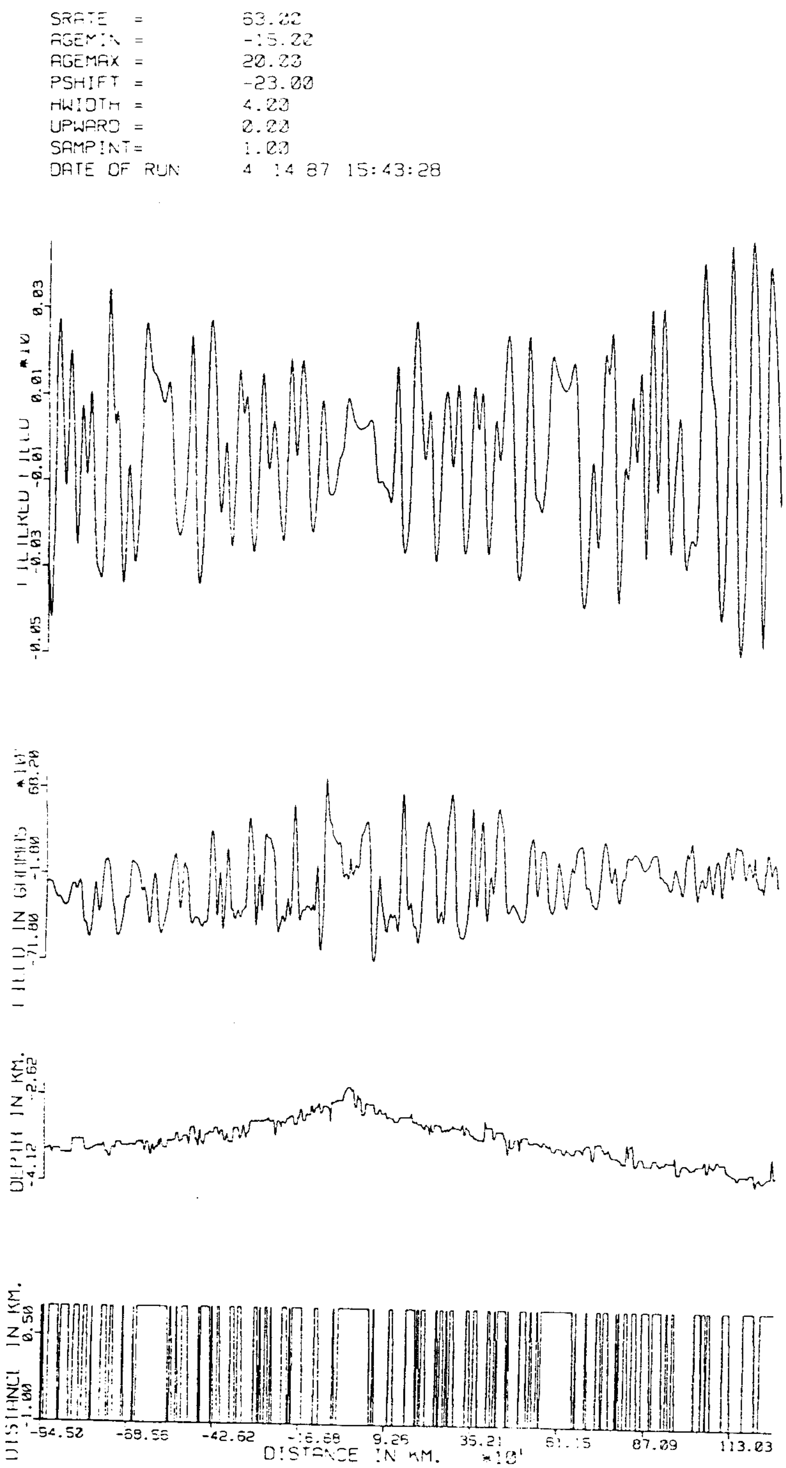

Figure 3. First attempt at modelling using the extended Fourier filtering method. The age at the left age is too large, as is the right edge. The gaussian filter seem too wide and the amplitude (y-scale) of the filtered synthetic profile is too large.

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **D** (*Create new synthetic based on errors in old*)

Anomaly creation Menu:

A.) Return to main menu

B.) Create an anomaly by edge addition

C.) Create an anomaly by Fourier smoothing, flat top and bottom

D.) Create an anomaly by Fourier smoothing, with topography and flat bottom

E.) Create an anomaly by Fourier smoothing, with topography and bottom mimics topography

F.) Create an anomaly by Fourier smoothing, with separate topography and bottom

G.) Exit from MAGANOM

Choice > **E**

Enter filename that contains anomaly variables,

* to read in variable changes from terminal.

<DEFAULT VALUES>: ***** (*Make changes at terminal*)

Enter values to be changed, always real, separated by a comma.

AGEMIN=-10.0 (*Reduce left-hand age*)

AGEMAX=14.0 (*Reduce right-hand age*)

SCALEF=0.007 (*Increase filtered plot scale factor*)

HWIDTH=3.0 (*Decrease Gaussian width to show higher frequencies*)

≤ CNTRL - Z ≥ (*End list of changes, calculate synthetic*)

<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>
.... VAX VERSION AUGUST, 1981 ....
NWORKING =499997;INDEX = 2;IRESET = 2

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile
B.) Enter a blockmodel
C.) Create a blockmodel
D.) Create an anomaly
E.) Filter an anomaly
F.) Output profiles and/or variables
G.) Spawn a subprocess (leave MAGANOM for a minute)
H.) Exit from MAGANOM
Choice > **E**

Anomaly filtering Menu:

A.) Return to main menu
B.) with Hans Schoutens Earth filter
C.) with Phase Filter
D.) with Upward/Downward Continuation
E.) with Gaussian distribution
F.) Exit from MAGANOM
Choice > **E** (*Filter as before*)
Do you wish to filter the filtered array (Y or N) ?
DEFAULT= "N"
<RET>
<<<<<<<<<< PATSY TIME-SERIES PROCESSOR >>>>>>>>>>
.... VAX VERSION AUGUST, 1981 ....
NWORKING =499997;INDEX = 2;IRESET = 2
Enter file name with filter variables "*" to read from term. <DEFAULT> : **<RET>**

Main Menu:

A.) Enter an anomaly, bathymetry or mantle interface profile

B.) Enter a blockmodel

C.) Create a blockmodel

D.) Create an anomaly

E.) Filter an anomaly

F.) Output profiles and/or variables

G.) Spawn a subprocess (leave MAGANOM for a minute)

H.) Exit from MAGANOM

Choice > **F** (*Display as before*)

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **C**

Profiles available for plotting :

A.) Return to output menu

B.) Block model

C.) Bathymetry

D.) Observed field

E.) Calculated field

F.) Filtered field

G.) Filtered filtered field

H.) Difference between observed and calculated

I.) Plot profiles chosen

J.) Exit from MAGANOM

Enter profiles as a list, separated by commas, up to 9 (I.E. A,B,C,D,I)

Choices > **B,C,D,F,I**

PLOTT 1.6 Mar 82; U.T.I.G. Version Sept 83.

For <plotdfer> file with logical-name FOR095.

Defaults: No pause, auto-window, go.

ENTER SIZE_FACTOR, FIRST_SUB_IMAGE, LAST_SUB_IMAGE: **<RET>**

PAUSE BETWEEN SUB_IMAGES? (Y OR N): **<RET>**

CALCULATE AUTO_WINDOW? (Y OR N): **<RET>**

X_ORIGIN = -0.5712417 Y_ORIGIN = -0.7407942

X_LENGTH = 7.240482 Y_LENGTH = 14.94796 INCHES.

W FOR WINDOW, G FOR GO: **<RET>**

(SEE FIGURE 4)

G FOR GO, C FOR CURSOR (O=LOWER-LEFT; W=UPPER-RIGHT), W FOR WINDOW, F FOR FIRST W, Q FOR QUIT: **Q**

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plott)

C.) Build plot file, then (optionally) plot with plott

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **B** *(Output profiles to different plotter so there is a permanent record)*

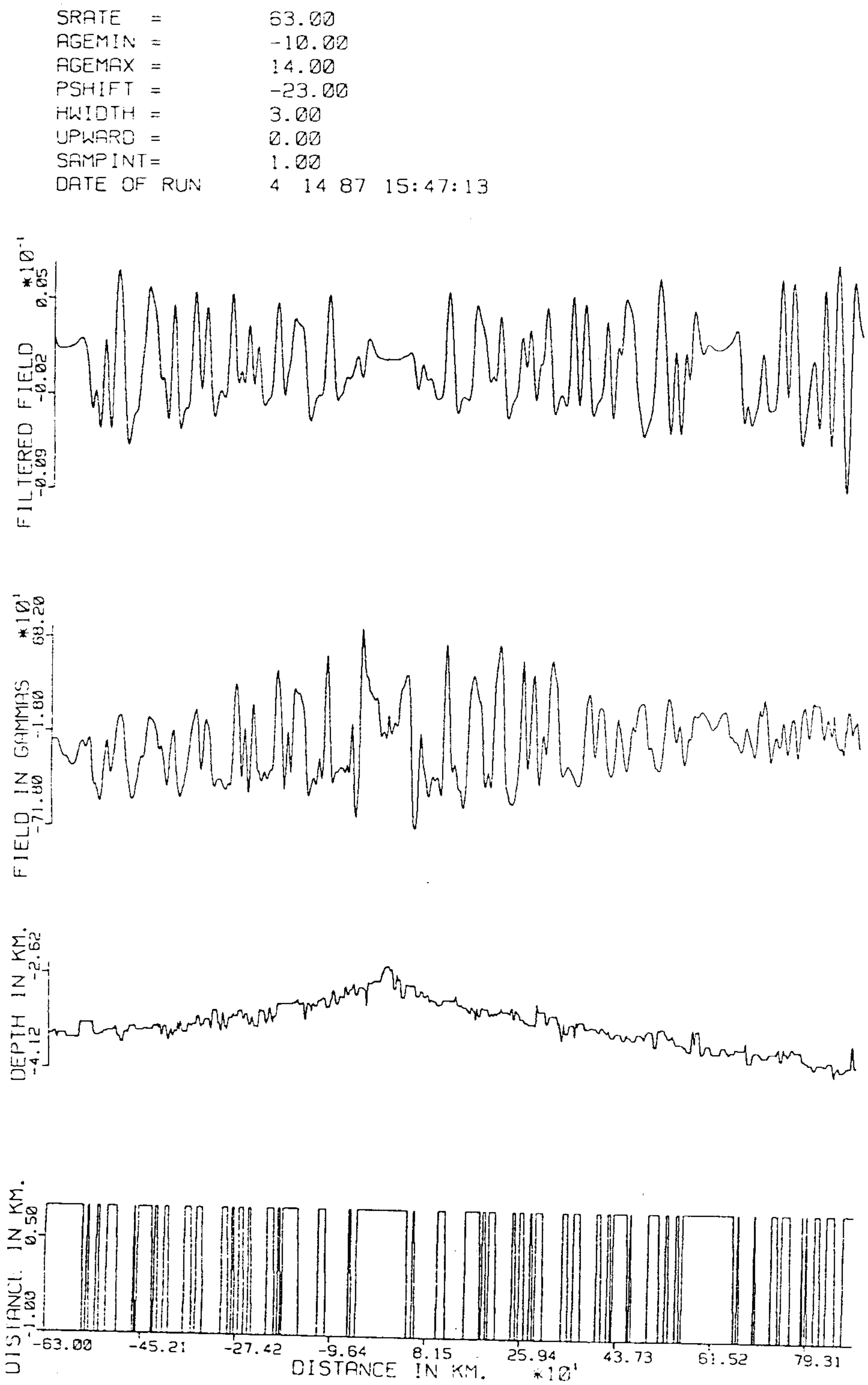

Figure 4. Second attempt at modelling using the extended Fourier filtering method. The result is remarkably good.

Change default plotter menu.

A.) Return to output menu

B.) Change to Versatec Plotter

C.) Change to Tektronix Plotter

D.) Change to Gould DeAnza Plotter

E.) Change to Calcomp Plotter

F.) Exit from MAGANOM

Choice > **B**

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plotv)

C.) Build plot file, then (optionally) plot with plotv

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **C**

Profiles available for plotting :

A.) Return to output menu

B.) Block model

C.) Bathymetry

D.) Observed field

E.) Calculated field

F.) Filtered field

G.) Filtered filtered field

H.) Difference between observed and calculated

I.) Plot profiles chosen

J.) Exit from MAGANOM

Enter profiles as a list, separated by commas, up to 9 (I.E. A,B,C,D,I)

Choices > **I** (*Short cut!! If just letter I is chosen, MAGANOM will plot only the entire previous plot*)

PLOTV.....UTIG.....C.R. Denham

For <plotdfer> file with logical name FOR095. (*PLOTV makes a paper plot*) Defaults:
All sub_images, auto_window, go.

ENTER SIZE_FACTOR, FIRST_SUB_IMAGE, LAST_SUB_IMAGE: **<RET>**

NOW CALCULATING AUTO_WINDOW ...

X_ORIGIN = -0.5712417 Y_ORIGIN = -0.7407942 INCHES

X_LENGTH = 7.240482 Y_LENGTH = 14.94796 INCHES

SIZE_FACTOR = 1.000000 PAPER_LENGTH = 8.240482 INCHES.

USE THIS AUTO-WINDOW FOR PLOT? (Y OR N): **<RET>**

W FOR WINDOW, G FOR GO: **<RET>**

Plot spooled to plotter GAMBITA as plot job 1 END OF <PLOTV>.

Output Menu:

A.) Return to main menu

B.) Change default plotting device (now is: plotv)

C.) Build plot file, then (optionally) plot with plotv

D.) Write profile data to an output file or screen

E.) Write (to file or screen) and/or change present variables

F.) Exit from MAGANOM

Choice > **E** (*Output variables of calculation so user has permanent record and can repeat result*)

Enter filename for output, * for term <*>: **<RET>**

General Variables

Variable Name	Function	Present Value
SRATE	Spreading half rate, in mm/yr	63.00
AGEMIN	Minimum age to use from timescale, in Ma	-10.00
AGEMAX	Maximum age to use from timescale, in Ma	14.00
HWIDTH	Half width of Gaussian filter, in Km.	3.00

UPWARD	Amount of upward continuation, in Km.	0.00
PSHIFT	Schouten-MCamy phase shift, in degrees.	-23.00
TOP	Top of magnetic layer, in Km.	3.20
BOTTOM	Bottom of magnetic layer, in Km.	4.00
STRIKE	Strike of ridge crest, in degrees.	40.00
NLAYERS	Number of layers in Fourier topo raster	5
DATE	Date of observation, A.D.	1962.00
OLAT	Old latitude of observation, in degrees.	-120.00
PLAT	Present latitude of observation, in degrees.	-51.00
PLON	Present longitude of observation, in degrees.	-120.00
FPAGE	Age of fixed point, in Ma (NGDC output)	0.00
FPLAT	Lat. of fixed point, in De (NGDC output)	23.00
FPLON	Lon. of fixed point, in De (NGDC output)	10.00
HEADING	Heading from fixed point (NGDC output)	77.00
MAX_AMP	Max amplitude of output (NGDC output)	300.00

Type <RET> to continue list or enter variable
name and new value as a real number, separated by =
to change (I.E. SRATE=23.1). Type <Q> or <q> to quit list
Type <L> or <l> to type this part of the list again.

<RET> (*See next page of variables*)

Variable Name	Function	Present Value
SAMPINT	Fourier sample interval,in Km.	1.00
BATHPOINTS	Number of observed bathymetry samples	1024
BLOCKPOINTS	Number of block model samples	1024
MAGPOINTS	Number of observed magnetic samples	1024
MANTPOINTS	Number of observed mantle samples	1024

Plot Variables

Variable Name	Function	Present Value
SCALEXFLDS	Horiz. scale, calculated field, in km/in	240.00
SCALEXOBS	Horiz. scale, observed field, in km/in	240.00
SCALEXSYN	Horiz. scale, syn. blockmodel,in km/in	240.00
SCALEB	Vert. scale, bathymetry profile, in km/in	1.50

SCALEC	Vert. scale, calculated profile, in gm/in	-2.000
SCALED	Vert. scale, difference profile, in gm/in	-2.000
SCALEF	Vert. scale, filtered profile, in gm/in	0.007
SCALEO	Vert. scale, observed profile, in gm/in	700.00

Type <RET> to continue list or enter variable
name and new value as a real number, separated by =
to change (I.E. SRATE=23.1). Type <Q> or <q> to quit list
Type <L> or <l> to type this part of the list again.
Q (*End of listing function*)

Output Menu:

A.) Return to main menu
B.) Change default plotting device (now is: plotv)
C.) Build plot file, then (optionally) plot with plotv
D.) Write profile data to an output file or screen
E.) Write (to file or screen) and/or change present variables
F.) Exit from MAGANOM
Choice > **F** (*End of complex example*)

1-6. Mathematical foundations of MAGANOM

MAGANOM offers two very different approaches to calculating the residual magnetic anomaly above a two dimensional magnetic source body: Edge Addition, and Fourier Filtering. Each method is designed to solve a different magnetic problem. Edge Addition is good at calculating anomalies above a magnetic source body of arbitrary size and shape. Fourier Filtering is good at calculating seafloor spreading anomalies, including seafloor with rough topography. These techniques have been combined into one program so that output from either technique can share filtering algorithms and output options. The theoretical basis from which the source code algorithms were derived is outlined below (Section 1-6-1 and 1-6-2).

This section also contains a description of the effect of the filters built into MAGANOM. Section 1-6-3 is a pictorial encyclopedia of the effect of the upward/downward continuation filter, phase shifting, Gaussian distribution, and the earth filter on the same unfiltered synthetic anomaly. The user can use this section to decide which filters to use and in what combination to use them by simply observing the effect of the filters displayed.

1-6-1. The Fourier Filtering Technique

The Fourier filtering technique is a computationally efficient method to calculate and/or filter synthetic magnetic anomalies. It is based on the technique outlined by Schouten (1971) and Schouten and McCamy (1972). This method takes advantage of the speed and ease of Fourier domain calculations. The technique operates on the premise that filters for a time series can be designed that produce effects on that series similar to the effects of the forces felt by a magnetic field frozen into a region of crust. The filters are applied to a time series that mimics the magnetic field frozen into the crust to calculate a synthetic times series that simulates the observed residual magnetic field. Most of the desired effects of filters that would be applied to the magnetization of the crust time series are frequency related. Frequency-dependent filtering in the time domain requires convolution, which is not very efficient. Frequency dependent filtering in the Fourier domain is accomplished by simple multiplication, and is therefore very efficient.

The principal advantage to the Fourier filtering technique is speed of calculation, which makes it especially useful for creating synthetic seafloor spreading anomalies for long portions of the geomagnetic timescale. The speed of calculation also allows more iteration and experimentation than does Edge Addition, which is significantly slower. Fourier filtering also offers the advantage of easy application of filters. The disadvantages of the method are that it cannot model the anomaly above a two dimensional magnetic source of arbitrary size and shape, and the values that are calculated are dimensionless.

Fourier synthetic sea floor spreading magnetic anomalies by be created MAGANOM in one of two ways. The simple method (section 1-6-1a) assumes that the top of the magnetic layer has no topography, and calculates the synthetic anomalies in one pass. The extended method (section 1-6-1b) incorporates sea floor topography into the calculation process by making multiple passes through the crustal profile. Although the extended method takes longer than the simple method, both are orders of magnitude faster than the Edge Addition method.

As neither Fourier method is intuitively obvious to a user that has not had training in time series analysis, the following two sections are devoted to outlining the theory behind the Fourier filtering technique.

1-6-1a. Simple Method

The simple Fourier Filtering technique for generation of synthetic seafloor spreading magnetic anomalies is based on a plane layer model. In this method, the sea floor is assumed to be flat, and the normal and reversed polarity of the crust is assumed to be of equal and opposite magnitude. The magnetization distribution is therefore a function of the horizontal distance (x) only. The magnetization of that crust can then be described as an equally sampled time series j(x) which contains only the values +ß or -ß, where ß is the magnitude of the magnetization (usually set to 1). These values represent positive or negative polarity as a function of distance. The pattern of polarity reversals can be deduced from the geomagnetic timescale, the sample interval, and the spreading rate.

The magnetization time series can also be completely described by the function J(s), the Fourier transformation of j(x), where J(s) is a complex function in which the wave number "s" is equal to 2Π divided by the wavelength. The series J(s) can be computed using the Fast Fourier Transformation algorithm and efficiently filtered in the Fourier domain to get the desired results (Schouten, 1971;

Schouten and McCamy, 1972; C.R. Denham, pers. comm., 1986). The application of various filters to the series J(s) is an integral part of the Fourier Filtering technique. The filters applied to the magnetized crust time series represent quantifiable earth parameters. It is these filters that change the magnetization time series J(s) into the synthetic magnetic anomaly M(s).

A time series in the Fourier domain is described by a complex function. The real part of the function describes the variations in amplitude of the series. The imaginary part of the complex function describes any variation in phase.

When modeling m(s), the calculated magnetic anomaly (or M(s), the calculated anomaly in the Fourier domain), the magnetization distribution is calculated assuming that the observations are made from directly above the magnetized layer and that the magnetization frozen in the crust is vertically alternating (i.e. the magnetization contains only the vertical component of the magnetization). When MAGANOM calculates a anomaly with Fourier filtering, it first calculates a magnetization distribution, then automatically applies two filters to it. These filters change the two assumptions so that the synthetic anomaly calculated portrays the actual situation more realistically. The filters that are applied simply modify the amplitude and the phase of the magnetization signal to achieve the desired synthetic observed anomaly.

The first filter that is applied to the magnetization distribution in the Fourier domain is the "earth filter" (Schouten, 1971; Schouten and McCamy, 1972). The term "earth filter" has slightly different usages. One usage means a filter that has the phase filter combined with the earth filter into one complex filter. In this text, we choose to use the strict definition that separates the earth and the phase filter. The earth filter is a complex function in which the imaginary part is empty. This function varies the amplitude of the magnetization signal, without changing the phase.

The earth filter controls the distance above the magnetized layer at which the field is simulated by allowing the magnetic signal to decay at an inverse exponential rate away from the source, as in:

$$E(s)= C_p(e^{-a[s]}-e^{-b[s]})$$

where

s = wavenumber

a = depth to top of source

b = depth to bottom of source

C_p = amplitude coefficient

The amplitude coefficient is calculated with the equation:

$$C_p= (\sin(I)/\sin(I'))^2 \;, 0 \leq C_p \leq 1$$

in which:

I = present inclination

I' = effective inclination, $\tan(I')= \tan(I)/\sin(\partial)$

∂ = strike of source with respect to magnetic north

Because present day anomaly fields are not caused by simple vertical fields frozen into the crust, but by complex interaction between two non-vertical fields: the effective inclination and declination of the present field and the effective inclination and declination of the remnant field, the Fourier method contains another component to recreate this complexity. This is the phase filter. The phase filter accounts for this interaction of these two forces by computing a constant angle Ø (called "phase shift" or "skewness") which is applied only to the imaginary part of the magnetization distribution in the Fourier domain.

The effective inclination and declination of the present and the remnant field is simply a function of the latitude and longitude of observation/creation, and the the strike of the ridge axis that is creating it. The skewness is calculated using trigonometric functions to break the two forces into vectors, and summing them, such that:

$$[E(s)] = e^{-i\emptyset}$$

where

$-i = \sqrt{-1}$
$\emptyset$ = Phase parameter = $I'_p + I'_r - 180°$
I'_p = present effective inclination
I'_r = remnant effective inclination

The effective inclination is calculated by the equation:

$$I' = \tan^{-1} (\tan(I)/\sin(\partial))$$

where

I = inclination
∂ = strike of source with respect to magnetic north

In the modeling, the user changes the maximum and/or minimum age assigned to the crust, the spreading rate, and/or the sampling interval, which in turn changes the distribution of +1 and -1 in j(x). This will change the appearance of the synthetic anomaly and therefore the correlations with the observed.

1-6-1b. Extended Method

The extended method for Fourier filtering is simply the repeated application of the simple method to magnetic source layers of complex topography. It allows topography on the seafloor to be integrated into the calculation of the synthetic anomaly. It is sometimes important to include topography into calculation of magnetic anomalies because a large part of the anomaly observed along a profile can be caused by mass deficiencies and excesses preserved in the topography, especially profiles of high relief at shallow depths.

The extended method incorporates topography into the calculation by simply dividing the magnetic source layer into a series of flat slices, calculating the magnetic anomaly for each slice by the simple method, then summing the anomaly profiles. Each slice is sampled as a series of cells of equivalent size that contain either water, non-magnetized crust, or magnetized crust. Each cell of magnetized crust is a assigned positive or negative polarity, based on the minimum and maximum age, the spreading rate, and the sampling interval. The magnetization values in each times series are set to 0, ß, or -ß. A value of 0 represents water or crust with no magnetization. Any other value for ß represents magnetized crust, where the sign of ß is the polarity and the amplitude of ß represents the relative amplitude of magnetization (usually set to 1). The simple Fourier filtering method (see Section 1-6-1a) can then be applied to the time series that represents each slice, and the effect of each sliced summed to get the net magnetic effect of the total magnetic source layer. Since the top and bottom of each slice is implicit in the simple Fourier filtering calculation, the varying depth for each slice is not a problem.

1-6-2. The Edge Addition Technique

The Edge Addition technique offered by MAGANOM is based on the program MAGCHECK, by Dr. John D. Mudie (K.D. Klitgord, pers. comm.). It is a straightforward and effective method for calculating a synthetic residual magnetic anomaly above a source of arbitrary size and shape. It can also calculate a synthetic seafloor spreading magnetic anomaly for crust with a flat top and bottom. It offers the following advantages:

1) It can calculate the anomaly above a two dimensional magnetic source of arbitrary size and shape.

2) The values that it calculates have dimensions equivalent to measurements of magnetic anomalies. The values calculated with the Fourier Filtering technique are scaled to a unit vector and are dimensionless.

3) The algorithm used in the calculation is easily understood and debugged.

The major disadvantages to this method are that the input is cumbersome, and the calculations are slow, especially for seafloor spreading anomalies.

The algorithm for calculating a synthetic anomaly using edge addition is straightforward. The user establishes the outline of a two dimensional magnetic body as a series of line segments defined by endpoints (X_n, Z_n), where n is an arbitrary number of points, X is the horizontal distance, and Z is the depth of the endpoint. The only rule is that the endpoints must proceed in a clockwise fashion around the body, and it must enclosed a region (i.e. the first and last endpoint must be the same). The user also establishes an observation profile as a series of points (X_n, Z_n), where n is an arbitrary number, X is the horizontal distance, and Z is the height above the body. The last piece of information that the user establishes is a three dimensional vector that represents the field frozen in the source. MAGANOM decomposes that vector into a two dimensional vector in the plane of calculation. MAGANOM also calculates a three dimensional regional magnetic field vector based on the spherical harmonic coefficients of the International Geomagnetic Reference Field, the latitude and longitude of the location of the calculation, and the date of observation. MAGANOM then projects this vector onto the two dimensional calculation plane as well.

The calculation begins by decomposing and then summing the regional and source field vectors together to obtain a single final dipole field within the source body. For every observation point, MAGANOM works its way around the outline of the source body, projecting the final dipole field vector onto each line segment defining the body. Each edge is then treated as a dipole, and the effect of that edge is calculated based on its distance from the observation point. Finally, the effect of each edge is summed (hence the name, Edge Addition).

There are only three types of calculations that MAGANOM makes when it does Edge Addition: projection of a three dimensional vector onto a two dimensional surface, decomposition of a two dimensional vector into parallel and perpendicular vectors, and calculation of the effect of a dipole at a point an arbitrary distance away. The projection and decomposition of vectors is accomplished by standard spherical Euclidian relationships (Emilia and Bodvarsson, 1969). The effect of a dipole is calculated with solid angle relationships (Dobrin, 1952, p. 495).

1-6-3. Effect of Filters

MAGANOM offers four filters. They are the earth filter, phase filter, upward/downward continuation filter, and the Gaussian distribution filter. The effects of these filters are outlined pictorially in Figures 5 through 8.

The earth filter is used in the Fourier method to decay a crust magnetization series to a synthetic magnetic anomaly, but it has other uses as well. It is offered as

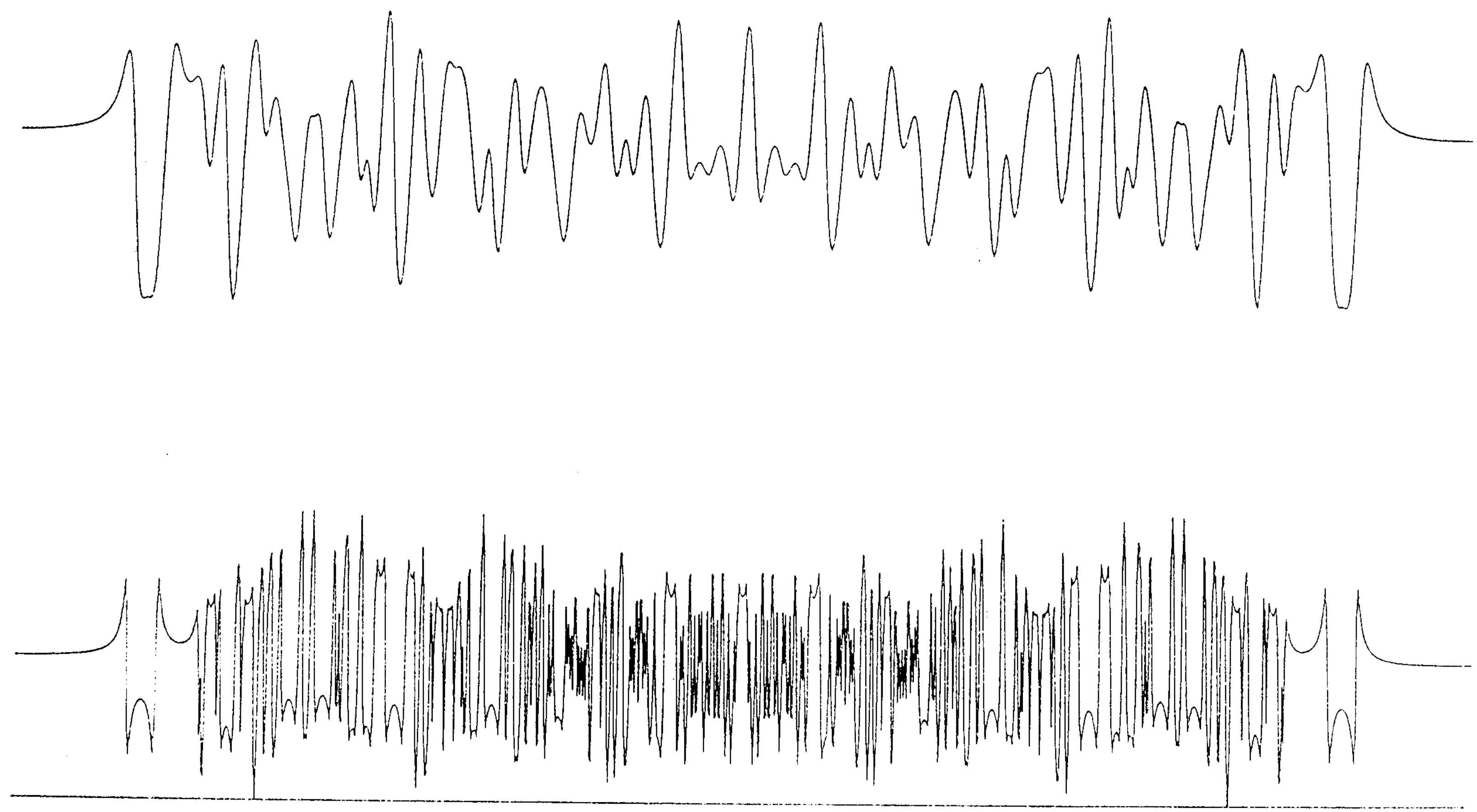

Figure 5. Effect of the Guassian Filter. Bottom profile is unfiltered. Top profile has been filtered with a gaussian filter. Half width of guassian curve=4.0 km. , spreading rate= 70 mm/yr, minimum age=-100.0 Ma., maximum age=100.0 Ma.

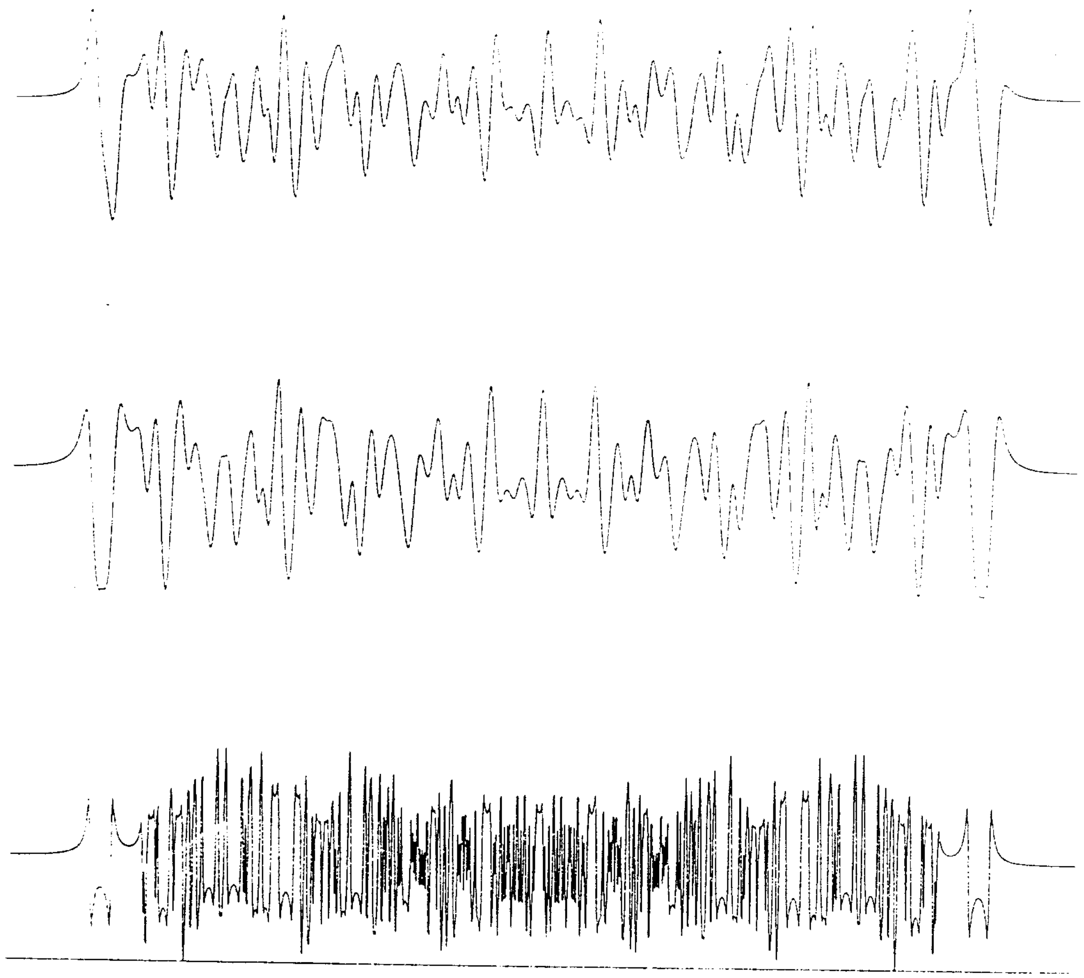

Figure 6. Effect of the Guassian Filter and Phase Shift. Bottom profile is unfiltered. Middle profile has been filtered with guassian filter only. Top profile has been filtered with a gaussian filter and a phase shift. Half width of guassian curve=4.0 km., Phase shift=45° , spreading rate= 70 mm/yr, minimum age=-100.0 Ma., maximum age=100.0 Ma.

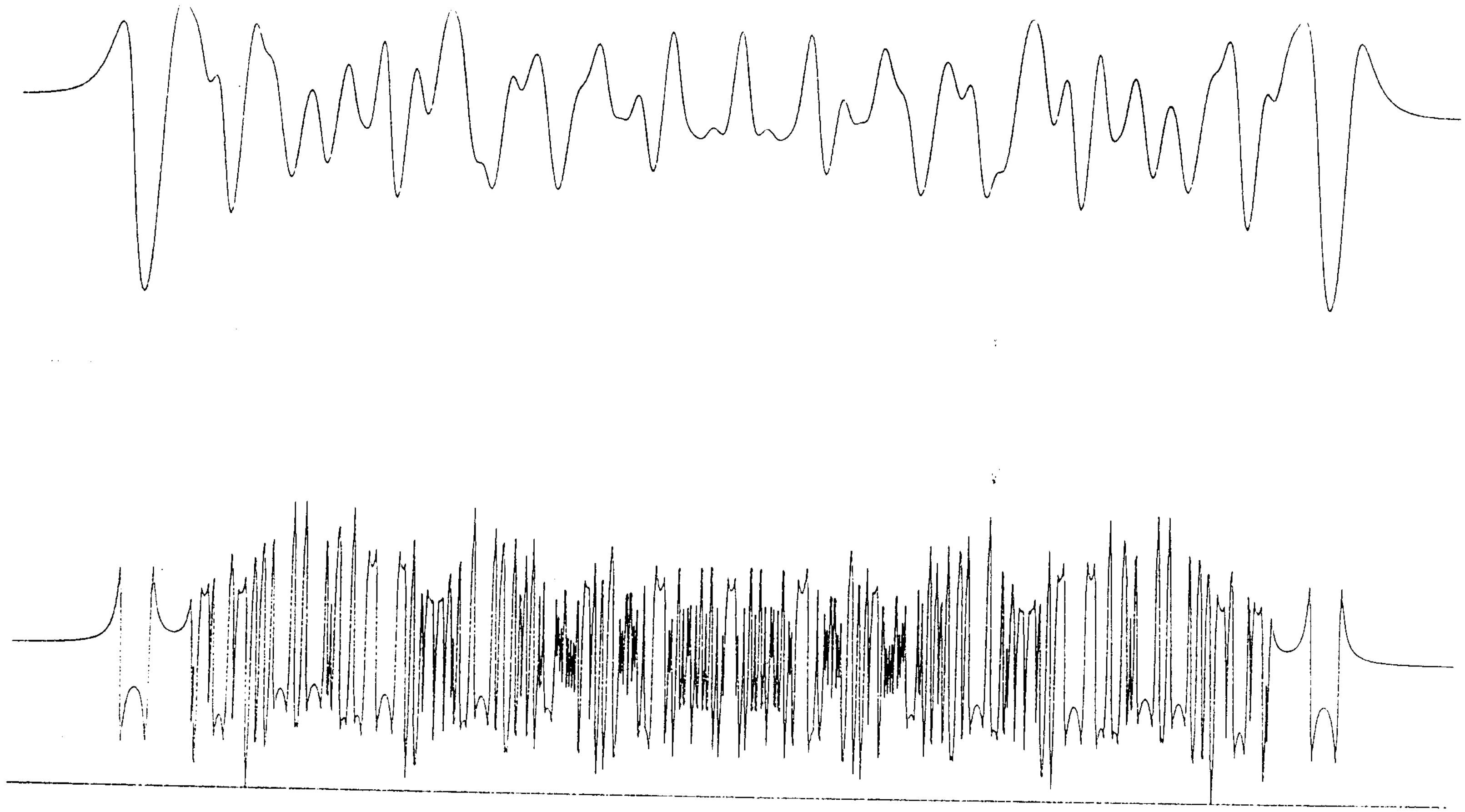

Figure 7. Effect of Upward Continuation. Bottom profile is unfiltered. Top profile has been upward continued. Upward continuation=10.0 km., spreading rate= 70 mm/yr, minimum age=-100.0 Ma., maximum age=100.0 Ma.

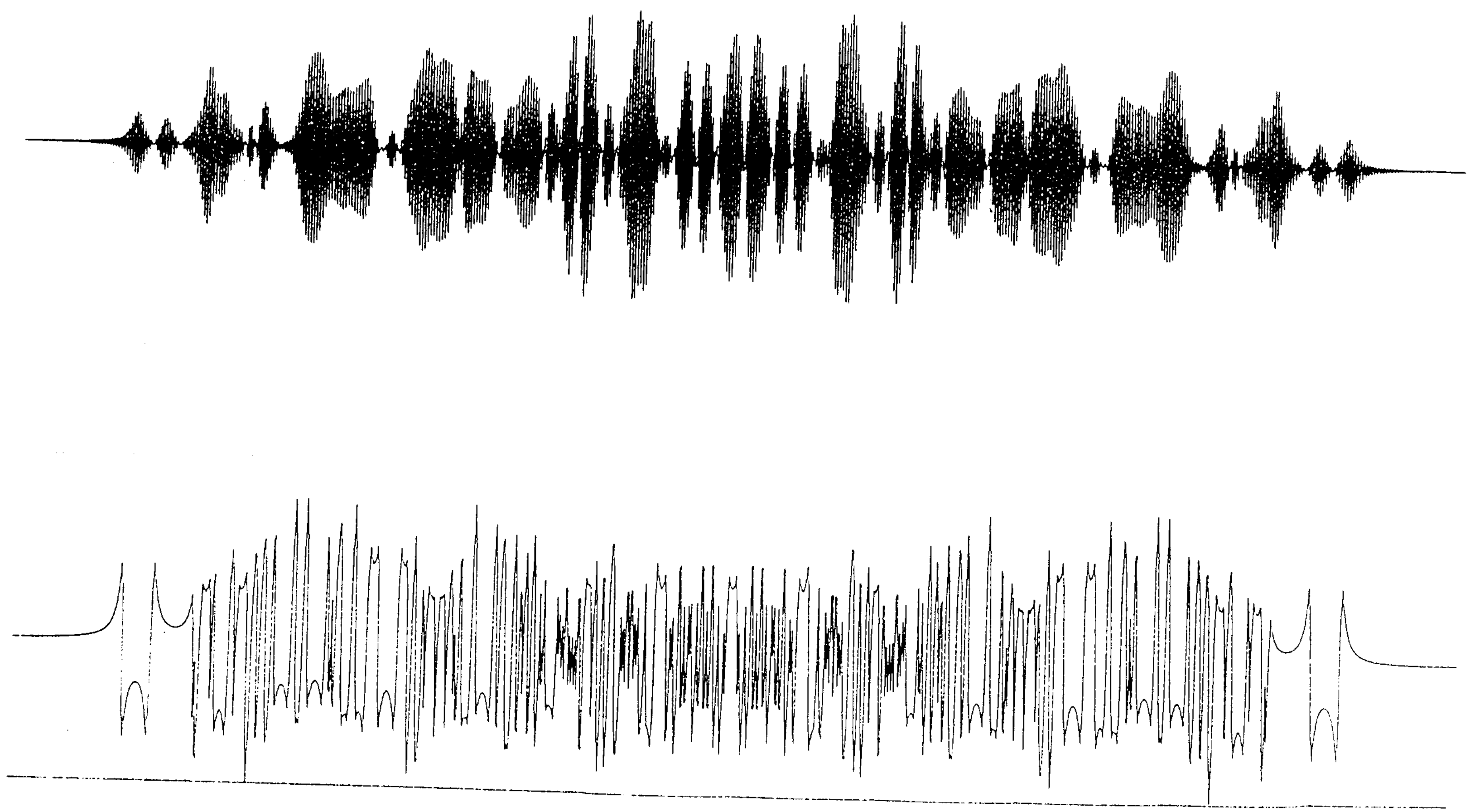

Figure 8. Effect of Downward Continuation. Bottom profile is unfiltered. Top profile has been downward continued. Downward continuation=-10.0 km., spreading rate= 70 mm/yr, minimum age=-100.0 Ma., maximum age=100.0 Ma.

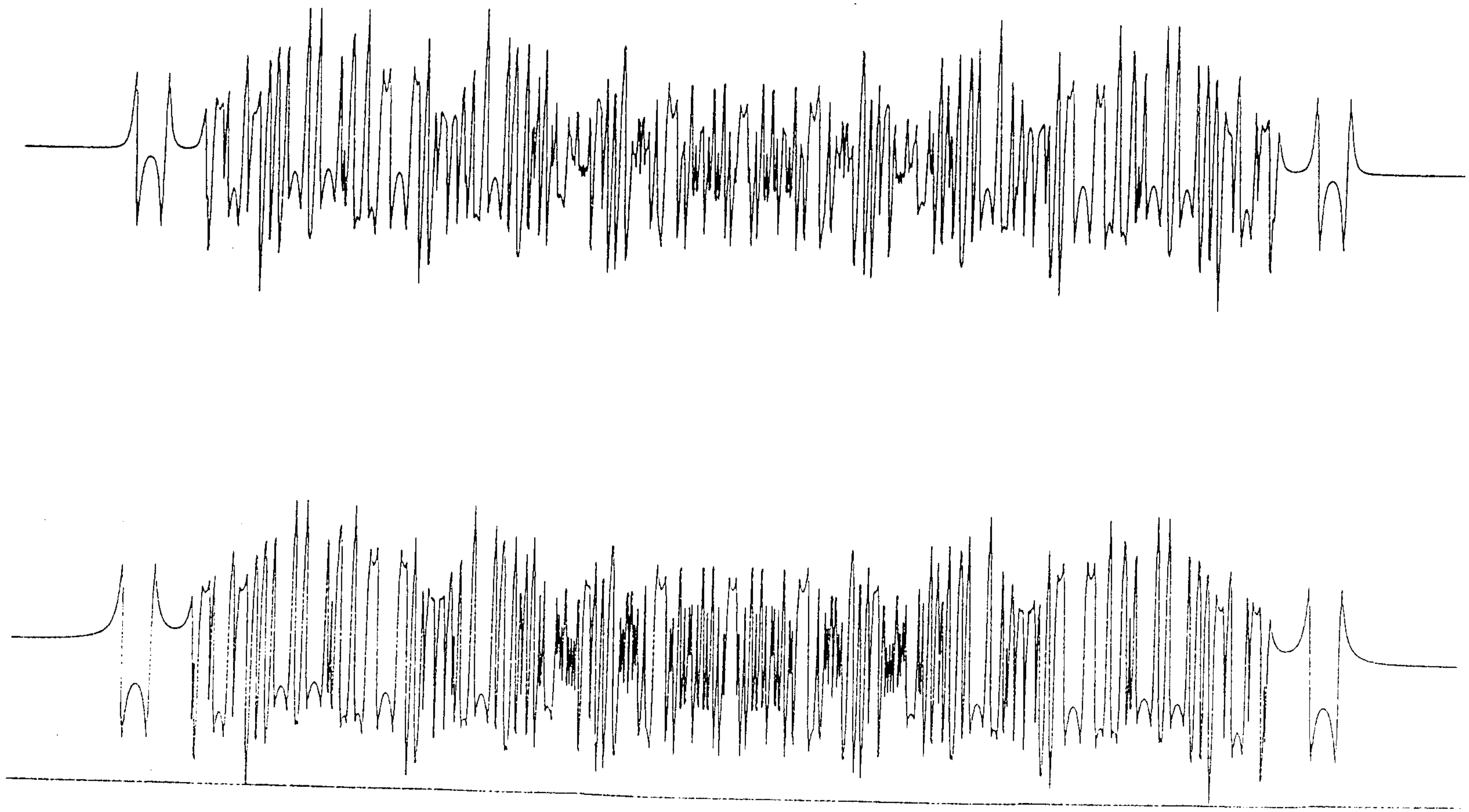

Figure 9. Effect of the Earth Filter. Bottom profile is unfiltered. Top profile has been earth filtered. Top=2.0 Km., bottom=3.0 Km., spreading rate= 70 mm/yr, minimum age=-100.0 Ma., maximum age=100.0 Ma.

a filter outside of the Fourier anomaly creation routine because it can be applied as complex logarithmic decay filter to do upward and downward continuation.

As discussed in Section 1-6-1, a user would apply the phase filter to a synthetic magnetic anomaly to "skew" it, that is, to account for the interaction between the effective inclination and declination of the present field and the effective inclination and declination of the remnant field.

Upward/downward continuation filters are applied to synthetic magnetic anomalies to smooth or enhance them by removing or amplifying their high frequency content. This has the effect of shifting the observation level for which the synthetic anomaly has been created. A user may wish to shift the synthetic anomaly upward (i.e. away from the magnetic source) to model the results of an aeromagnetic survey. A user may wish to shift the synthetic anomaly downward (i.e. closer from the magnetic source) to model the results of a deep-tow survey.

The Gaussian filter has a similar smoothing effect as the earth filter and the upward continuation filter, but is used for a different reason. Both the Fourier and the Edge Addition methods assume that the magnetic polarity reversal happen instantaneously. This introduces a high frequency bias to the synthetic anomaly, and is an artificial assumption. The dikes that make up the magnetic crust are observed to intrude over a range on either side of the intrusion axis. The Gaussian curve is bell shaped, and is used to represent this zone. The effect of passing the synthetic anomaly through the Gaussian filter is to remove any high frequency bias introduced by the instantaneous polarity reversal assumption.

1-7. Comments on the MAGANOM Source Code

MAGANOM is really a overlay program that draws on and links together several diverse system functions to produce a useful package with an easy interface. The system packages that are linked together are:
1) the UTIG PLOTDFER plotting routines and programs;
2) the PATSY library of Fast Fourier calculation subroutines;
3) the VECTOR library of geographic location subroutines; and
4) the MAGCHECK Edge Addition program.
PATSY, VECTOR, and PLOTDFER are with the courtesy and permission of Dr. Charles Denham. Any questions concerning these packages should be addressed to him at the address below. The MAGCHECK program is courtesy of Dr. Kim Klitgord, United States Geological Survey.

The source code for MAGANOM is not listed with the text for the following reasons:
1) brevity;
2) a large part of MAGANOM is system code and therefore cannot be included;
3) the source for MAGANOM is only the overlay and as such is not helpful; and
4) a listing of the code is available on the UTIG VAX computer.

Copies of the source code are available on the University of Texas Institute for Geophysics VAX 11/780. The code is stored in USR$DISK:[UTIGEXE.SOURCE] as filename "MAGANOM.FOR". Printed copies of the source are available by writing Malcolm I. Ross, c/o Institute for Geophysics, University of Texas at Austin, 8701 Mopac Blvd., Austin, Texas, 78759-8345, or calling 512-471-6156.

1-8. Listing of supplementary files

Listed below are the input files that were used in the sample runs of MAGANOM (Section 1-5).

The ELTANIN.DAT data file contains the variables used as the starting input of the simple modeling of ELTANIN 19, South Pacific (Section 1-5-1).

ELTANIN.DAT

```
SRATE=63.0,ALATM=-51.0,ALATF=-51.0,ALONF=-120.0,STRIKE=40.0
TOP=3.2,BOTTOM=4.0,AGEMIN=-15.0,AGEMAX=0.0
DATE=1962.0,HWIDTH=4.0,PSHIFT=-23.0
SCALEXSYN=240.0,SCALEXFLDS=240.0,SCALEXOBS=240.0
SCALEO=700.0
SCALEF=0.0030
SCALEB=1.5
```

The COMPLEX_EXAMPLE.DAT data file contains the variables used as the starting input of the complex modeling of ELTANIN 19, South Pacific (Section 1-5-2).

COMPLEX_EXAMPLE.DAT

```
SRATE=63.0,ALATM=-51.0,ALATF=-51.0,ALONF=-120.0,STRIKE=40.0
TOP=3.2,BOTTOM=4.0,AGEMIN=-15.0,AGEMAX=20.0
DATE=1962.0,HWIDTH=4.0,PSHIFT=-23.0
SCALEXSYN=240.0,SCALEXFLDS=240.0,SCALEXOBS=240.0
SCALEO=700.0
SCALEF=0.0020
SCALEB=1.5
```

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